CLAIMS

1) ***A new type of focal plane array*** — MULTICYCLE INTEGRATION FOCAL PLANE ARRAY (MIFPA), linear or area. Unlike the existing FPA, which uses single-cycle integration, MIFPA utilizes a few switches to perform on-chip multicycle integration.

2) ***Applications of MIFPA*** — TO DETECT EXTREMELY WEAK SIGNALS FOR IMAGING, SPECTROSCOPY, AND SPECTROSCOPIC IMAGING.

3) ***Three operational modes of MIFPA*** — LOCK-IN (LI-), GATED (G-), and GATED LOCK-IN (GLI-) MODES.

4) ***A new type of focal plane array*** — LOCK-IN MULTICYCLE INTEGRATION FOCAL PLANE ARRAY (LI-MIFPA), linear or area. LI-MIFPA has the following features:

a) It uses an active or passive modulator to modulate the signal;

b) It does not modulate dark and/or background current;

c) It uses a correlated multicycle integrator for each pixel, so that the signal current is accumulated while the background and/or dark current is cancelled;

d) The integration time of the LI-MIFPA can be many orders longer than that of the existing FPA technology;

e) Therefore, the signal to noise ratio, dynamic range, and low frequency or $1/f$ noise of the LI-MIFPA can be improved by many orders in comparison with the existing FPA technology.

5) ***Applications of LI-MIFPA*** — TO DETECT EXTREMELY WEAK SIGNALS FOR IMAGING, SPECTROSCOPY, AND SPECTROSCOPIC IMAGING.

6) ***A new type of focal plane array*** — GATED MULTICYCLE INTEGRATION FOCAL PLANE ARRAY (G-MIFPA), linear or area. The G-MIFPA has the same multicycle correlated integrator for each pixel as the LI-MIFPA, but is programmed to operate in the gated mode. The G-MIFPA has the following features:

a) It uses a pulsed light source to generate a repetitive signal (as in the case of IR fluorescence spectroscopy using nano-second pulse laser excitation);

b) The G-MIFPA is used when the number of integrated signal electrons is many orders smaller than that of the background and/or dark current electrons $\alpha I_s << I_b$, but αI_s is not $<< I_b$;

c) In G-MIFPA the direction of integration of the correlated multicycle integrator does not change as in the LI-MIPFA; The integrator is turned on by a trigger signal from the gate control circuit to integrate the signal photocurrent pulse, and turned off after a certain increment of time;

d) The integration time of the G-MIFPA can be many orders longer than that of the existing FPA technology;

e) Therefore, the signal to noise ratio, dynamic range, and low frequency or $1/f$ noise of the G-MIFPA can be improved by many orders in comparison with the existing FPA technology.

7) ***Applications of G-MIFPA*** — TO DETECT EXTREMELY WEAK SIGNALS FOR IMAGING, SPECTROSCOPY, AND SPECTROSCOPIC IMAGING.

8) ***A new type of focal plane array*** — GATED LOCK-IN MULTICYCLE INTEGRATION FOCAL PLANE ARRAY (GLI-MIFPA), linear or area. The GLI-MIFPA has the same multicycle correlated integrator for each pixel as the LI-MIFPA, but is programmed to operate in the gated lock-in mode. The GLI-MIFPA has the following features:

a) It uses a pulsed light source to generate a repetitive signal (as in the case of LWIR spectroscopy using nano-second pulse laser excitation);

b) The GLI-MIFPA is used when the signal is not only short, but is also associated with a much stronger background ($\alpha << 1, I_s << I_b$);

c) In GLI-MIFPA, the correlated multicycle integrator goes through three phases (Fig. 5.b). In $\phi 1$, which lasts $\alpha\tau$, the integrator integrates both the signal pulse and strong background currents. In $\phi 2$, which has the same duration as $\phi 1$, the integrator reverses its direction of integration, and cancels the background of $\phi 1$. In $\phi 3$, which lasts much longer than $\phi 1$ or $\phi 2$, the integrator is turned off.

d) The GLI-MIFPA combines the advantage of the G-mode — reduction of the on-time of the integrator to increase the integration time — and that of the LI mode — cancellation of background to increase the integration time;

e) Therefore, the signal to noise ratio, dynamic range, and low frequency or 1/*f* noise of the G-MIFPA can be improved by many orders in comparison with the existing FPA technology.

9) ***Applications of GLI-MIFPA*** — TO DETECT EXTREMELY WEAK SIGNALS FOR IMAGING, SPECTROSCOPY, AND SPECTROSCOPIC IMAGING.

10) ***A new device*** — CORRELATED MULTI-CYCLE INTEGRATOR (comprising of one operational amplifier or source follower and four MOS switches), which can be programmed to control the MIFPA to operate in lock-in (LI-), gated (G-), or gated lock-in (GLI) mode.

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